CRAGIEVARUS KITCHINGI BRINK, 1965: A SUBJECTIVE JUNIOR SYNONYM OF *DIADEMODON TETRAGONUS* SEELEY, 1894 (REPTILIA, THERAPSIDA)

By

F. E. Grine

South African Museum, Cape Town

(With 11 figures and 2 tables)

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ABSTRACT

The holotype of *Cragievarus kitchingi* has been re-examined. No other specimen has been referred to this taxon. The supposed diagnostic features of *Cragievarus kitchingi* are shown to be invalid; the type does not display morphology that serves to distinguish it from *Diademodon tetragonus*. Therefore, the name *Cragievarus kitchingi* Brink, 1965, is considered to be a subjective junior synonym of *Diademodon tetragonus* Seeley, 1894. The type specimen of *Cragievarus* is regarded as a subadult individual of *Diademodon tetragonus*.

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INTRODUCTION

The late Early to early Middle Triassic sediments of South Africa have yielded a large assemblage of moderately advanced, gomphodont cynodonts (Kitching 1977). The most commonly occurring forms in these deposits are a relatively homogeneous group of animals that has been placed in the subfamily Diademodontinae by Hopson & Kitching (1972).

Various diademodontine genera and species have been erected on often fragmentary remains from the late Early to early Middle Triassic sediments of South Africa and Zambia. Studies of cranial and dental morphology and analyses of the geographic and stratigraphic distributions of the diademodontine fossils have suggested that many, if not all, of the names that have been established (Table 1) are junior synonyms of *Diademodon tetragonus* Seeley, 1894 (Hopson 1971; Hopson & Kitching 1972; Kitching 1977; Grine 1977, 1978*b*). The results of allometric and multivariate statistical analyses of diademodontine crania have indicated that the specimens conform to a morphometri-

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TABLE 1
Proposed synonyms of *Diademodon tetragonus* Seeley, 1894.

*Cynochampsa laniaria**	Owen, 1859
Diademodon brachytiara	Seeley, 1894
Diademodon mastacus	Seeley, 1894
Diademodon browni	Seeley, 1894
Gomphognathus kannemeyeri	Seeley, 1895
Gomphognathus polyphagus	Seeley, 1895
Gomphognathus dimorphodon	Seeley, 1908
Diademodon entomophonus	Seeley, 1908
Gomphognathus minor	Broom, 1911
Diademodon platyrhinus	Broom, 1913
Trirachodon browni	Broom, 1915
Cyclogomphodon platyrhinus	Broom, 1919
Octagomphus woodi	Broom, 1919
Protacmon brachyrhinus	Watson, 1920
Gomphognathus grossarthi	Broili & Schröder, 1935
Gomphognathus broomi	Broili & Schröder, 1935
Gomphognathus haughtoni	Broili & Schröder, 1935
Sysphinctostoma smithi	Broili & Schröder, 1936
Protacmon reubsameni	Broom, 1950
Diademodon parringtoni	Brink, 1955
Diademodon laticeps	Brink, 1955
Diademodon rhodesiensis	Brink, 1963
Cragievarus kitchingi	Brink, 1965

*Application has been made to the International Commission on Zoological Nomenclature to conserve the name *Diademodon tetragonus* Seeley, 1894, with application of Articles 32a–b and 79 of the International Code of Zoological Nomenclature (Grine 1978a).

cally homogeneous group and that these crania represent an ontogenetic growth series of a single species (Grine & Hahn 1978; Grine, Hahn & Gow 1978; Bradu & Grine 1979).

Recently, however, Brink (1979) has proposed that the Diademodontinae comprises four species of *Diademodon*, viz. *D. tetragonus*, *D. mastacus*, *D. grossarthi*, and *D. rhodesiensis*, and an additional two generically separable taxa, *Sysphinctostoma smithi* and *Cragievarus kitchingi.*

The purpose of this paper is to evaluate the supposed diagnostic features and thus the taxonomic distinctiveness of *Cragievarus kitchingi* Brink, 1965. Whereas the species of *Diademodon* recognized by Brink (1979) are differentiated on cranial shape and proportions, and whilst *Sysphinctostoma smithi* is rediagnosed on supposed dental differences from *Diademodon* (Brink 1979), the diagnostic features of *Cragievarus kitchingi*, as will be shown below, are based on doubtful information and erroneous interpretations. Because of the peculiar problems presented by *Cragievarus kitchingi*, the type and only specimen of that taxon warrants detailed re-examination. Thus, *Cragievarus kitchingi* is dealt with here separately from the other supposed diademodontine taxa. The distinctiveness of the four *Diademodon* species recognized by Brink and the taxonomic validity of *Sysphinctostoma smithi* will be discussed in a future publication (Grine, in prep.).

MATERIAL AND METHODS

The holotype of *Cragievarus kitchingi* is in the collection of the Bernard Price Institute for Palaeontological Research, University of the Witwatersrand, Johannesburg, and is catalogued under Field Number 3776 and Museum Number 368. It was described by Brink (1965) and is the only specimen referable to that taxon (Brink 1979). It consists of an incomplete and rather poorly preserved skull found by J. W. Kitching in a 'fossil pocket' on the farm Cragievar, near Burgersdorp, Cape Province (Brink 1965; Kitching 1977). This small pocket also yielded a number of other diademodontine crania (Kitching 1963, 1977) that were referred originally to *Diademodon browni* (Brink 1963) and more recently to *D. grossarthi* (Brink 1979).

Recent examination of the type of *Cragievarus kitchingi* revealed a considerable amount of plaster of Paris reconstruction (Figs 3–5). The extent of this reconstruction was not readily apparent because the plaster had been painted to match the colour of the actual bone. The author has removed the plaster from the specimen and has performed some additional preparation, most notably in the removal of matrix from between the dentary and maxilla. Before any of this work was initiated, photographs, colour slides, and a silicone rubber mould of the specimen were taken; in addition, a plastic cast of the fossil, painted to resemble the specimen prior to cleaning, was made.

The original diagnosis, description and illustrations of the specimen were based upon the plaster reconstruction of the fossil (Brink 1965). In a later paper (Brink 1979), additions to the diagnosis of *Cragievarus kitchingi* and several quite significant modifications of the illustrative reconstruction of the specimen were made.

DESCRIPTION

As noted above, the purpose of this paper is to evaluate the supposed diagnostic features of the type of *Cragievarus kitchingi*, and as such a complete description of the specimen is not warranted. Rather, attention will be paid only to the features that have been stated (Brink 1965, 1979) as being peculiar to this specimen and as differentiating it from *Diademodon*. These characters are: (i) the delicate nature and shape of the temporal arch, (ii) the expansion of the ascending ramus of the dentary, (iii) the nature of the post-temporal fossa, (iv) the relative breadth of the braincase, (v) the height of the mid-sagittal parietal crest, (vi) tooth number, (vii) the length of the maxillary diastema, (viii) the replacement of the alisphenoid by the quadrate ramus of the pterygoid, and (ix) the divergence of the quadrate rami of the pterygoid.

Temporal arch

It has been stated that 'the peculiarity of the skull lies in the fact that it has the powerful extremely advanced lower jaw structure of a diademodontid. . . .

In sharp contrast, however, the zygomatic arch is delicate' (Brink 1965: 97). Furthermore, the arch of this specimen was considered to be a 'delicate, miniature *Diademodon*-like or *Trirachodon*-like arch, but it lacks evidence of a jugal process' (Brink 1965: 98). More recently, it was concluded that '*Cragievarus kitchingi* comes close to *Diademodon*, but it is best regarded as not a synonym because its zygomatic arches are conspicuously different (more slender, high, and less curved)' (Brink 1979: 7).

In both the 1965 and 1979 diagnoses of *Cragievarus kitchingi*, it was stated that the 'zygomatic arches [are] conspicuously reduced' (Brink 1965: 98, 1979: 43). To the later diagnosis was added that there is a 'weak jugal process (if any)'.

In an illustration of the right lateral side of the skull (Brink 1965) (Fig. 1 herein), a jugal flange is not present and the ventral border of the anterior portion of the jugal arch is drawn with a solid line, implying that this region is complete; posteriorly, the jugal-squamosal suture is represented intact with a suggestion that the posteroventral border of the squamosal is damaged; the squamosal crest is reconstructed as possessing a low, foreshortened profile. A later illustration, however, indicates that there might have been a slight jugal flange, and the squamosal crest is shown as having had a higher, posteriorly expanded profile (Brink 1979) (Fig. 2 herein). Here, too, the posteroventral border of the arch is represented as being relatively shallow but complete.

Comparison of Figures 3 and 4 (herein) indicates that the entire anterior portion of the temporal arch and the posterior parts of both the superior and inferior orbital borders are missing; thus, it is impossible to determine the size of the jugal flange because it is not preserved. In addition, the entire ventral border of the back of the arch (both the jugal and squamosal contributions) is damaged, and it is possible that this region extended further downwards for several millimetres.

The posterior crest of the squamosal is missing and has been illustrated as such (Brink 1965, 1979). The later reconstruction of this region (Fig. 2 herein) is considerably different from the earlier interpretation (Fig. 1 herein). Inasmuch as this part of the squamosal is not present in the original specimen, either (or neither) of the reconstructions could be correct. With a lack of concrete evidence indicating the configuration of a specific morphological feature, any reconstruction of it is hypothetical. It is particularly dangerous to incorporate such a reconstruction (e.g. the lack of, or the weak development of the jugal flange) into a taxonomic diagnosis.

The supposedly low degree of curvature, and the supposed slenderness and relatively delicate nature of the temporal arch of this specimen were considered to differentiate it from *Diademodon* (Brink 1965, 1979). The present author believes that these apparent features are artefacts of the damage that the arch has suffered. If the arch is extended ventrally in the front with the addition of a jugal flange and at the back with several millimetres of missing bone, then the supposedly straight contour and the delicate, slender appearance of the arch disappear.

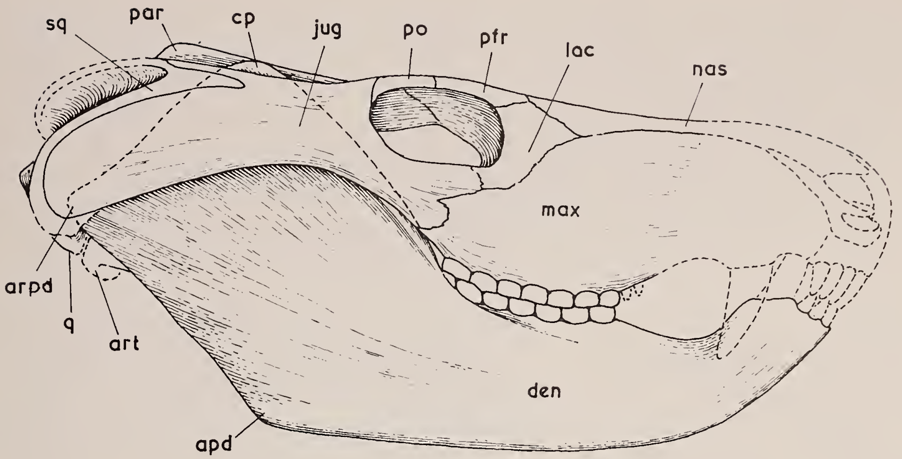

Fig. 1. Side view of the holotype of *Cragievarus kitchingi* as drawn by Brink (1965: 101, fig. 42).

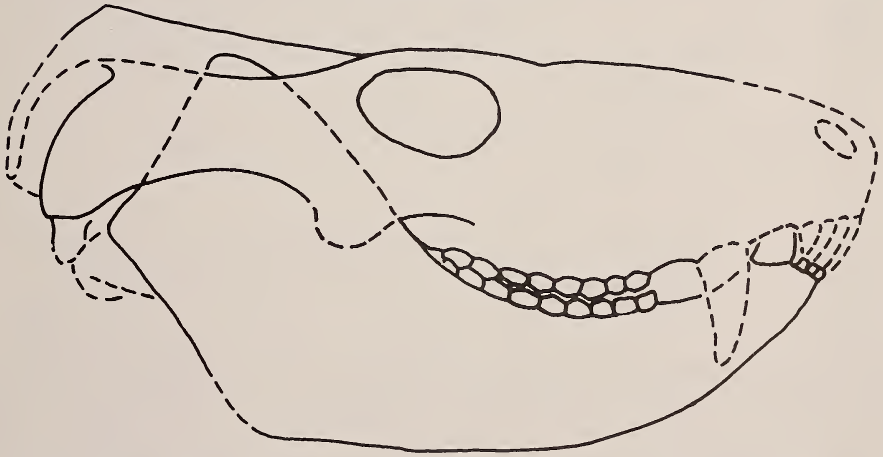

Fig. 2. Side view of the holotype of *Cragievarus kitchingi*, adapted from Brink (1979: 44).

Posterior expansion of the dentary

Brink (1965, 1979) stated that this specimen is 'diademodontid in general shape and structure, but with dentaries even more powerfully expanded posteriorly'. He noted the 'elaborate development' of the three portions of the ascending ramus of the dentary—the coronoid, articular and angular processes—and observed that 'the articular process reaches farther into the articular region and would appear to have had nearly direct contact with the squamosal' (Brink 1965: 105).

The earlier illustration of the dentary (Brink 1965, fig. 42) (Fig. 1 herein) shows the articular process of the dentary extending posterosuperiorly towards the squamosal, but in the later drawing (Brink 1979: 44) (Fig. 2 herein) this process is considerably foreshortened and does not reach even to the level of the inferior border of the temporal arch.

Examination of the specimen shows that the entire angular region of the dentary is missing from the right side (Fig. 4), but part of this region is preserved on the left side and it appears that the reconstruction of this region on the right is anatomically reasonable (Fig. 3). However, it is on the left side where the

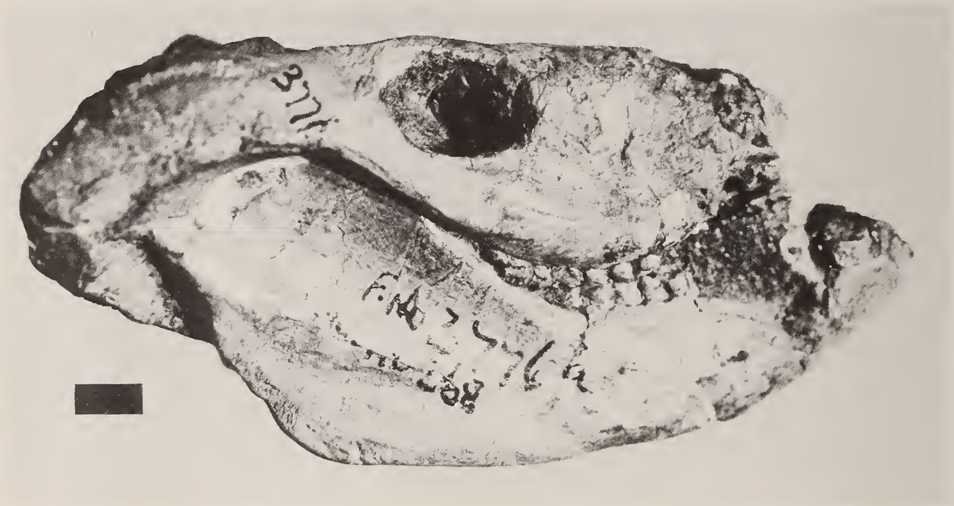

Fig. 3. Right lateral view of the holotype of *Cragievarus kitchingi* prior to the removal of the plaster (reconstructed) areas (cf. Figs 1–2, 4). Scale in cm.

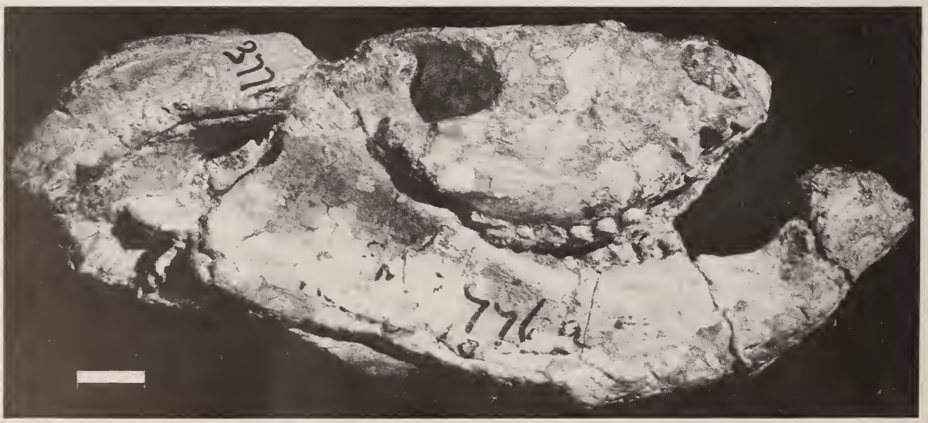

Fig. 4. Right lateral view of the holotype of *Cragievarus kitchingi* after the removal of the plaster (reconstructed) areas and some of the matrix (cf. Figs 1–3). Scale in cm.

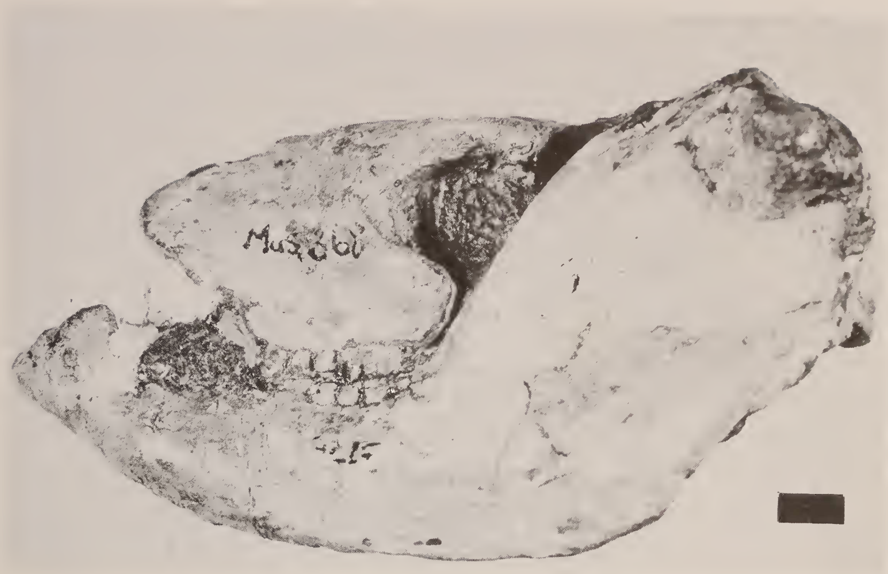

Fig. 5. Left lateral view of the holotype of *Cragievarus kitchingi* prior to the removal of the plaster (reconstructed) areas (cf. Fig. 6). Scale in cm.

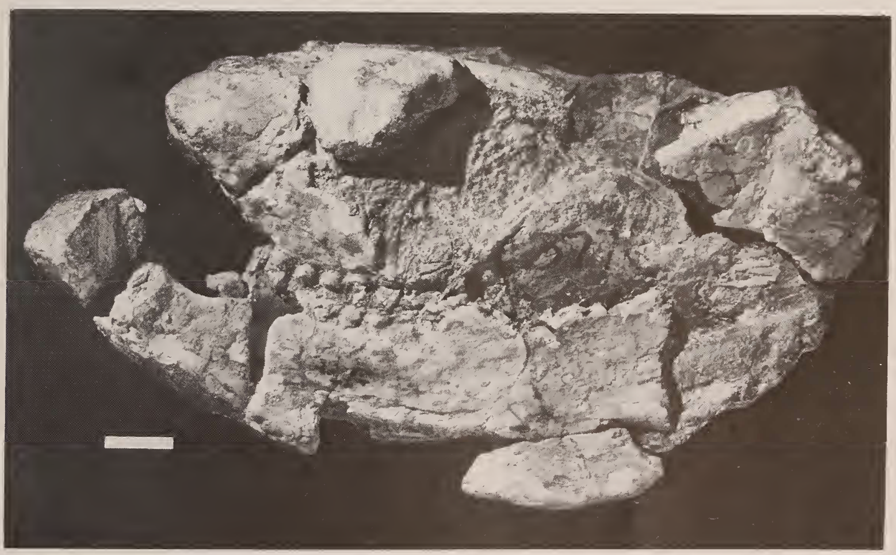

Fig. 6. Left lateral view of the holotype of *Cragievarus kitchingi* after the removal of the plaster (reconstructed) areas and some of the matrix (cf. Fig. 5). Scale in cm.

'powerful expansion' of the ascending ramus referred to and figured (Brink 1965, 1979) is best illustrated (Fig. 5). But here, too, much of the ascending ramus of the dentary has been reconstructed in plaster (cf. Figs 5–6). In fact, most of the left side of the cranium has been reconstructed, there being very little bone actually preserved.

Close examination of the left side of the specimen revealed an impression in the matrix of much of the inner surface of the ascending ramus of the dentary. Most notably, there exists the impression of part of the anterior margin of the ramus. The course of the anterior margin, as preserved as an impression, is at considerable variance with the course of this border in the plaster reconstruction (Fig. 7). The anterior margin of the dentary impression courses superoposteriorly, whilst in the reconstruction this border is considerably more vertically orientated. Over the lower third of the rameal height the plaster anterior margin is located about 6,0 mm in front of the actual (impression) border, and at a higher level the plaster margin is nearly 10 mm anterior to the margin of the impression. The mandibular reconstruction was modelled so that the anterior rameal margin met this margin as preserved on a piece of the tip of the coronoid process. However, this superior portion of the ramus is attached to a block of matrix that has been separated from the rest of the specimen (Fig. 6). There is no good contact between this block and the rest of the specimen, and it is evident that the tip of the ramus, as preserved on this piece, is positioned well out of normal anatomical alignment.

Thus, the 'powerful' expansion of the dentary ramus which was utilized in the diagnosis of *Cragievarus kitchingi* (Brink 1965, 1979), is based upon a reconstruction that departs from the original bony contours impressed in the matrix. Examination of the left and right mandibular rami of this specimen, in so far as they are preserved, indicates that they are expanded no more than in any *Diademodon* dentary of similar size.

Post-temporal foramen

It was originally claimed that 'a very peculiar aspect of this skull is to be found in the nature of the post-temporal fossa. On the right side the fossa is to be seen, on the side of the temporal vacuity, as a small shallow excavation extending directly inward in the direction of the brain case. On the posterior face there is only a depression with no sign of an opening. The region is not distorted to any degree so that an explanation cannot be sought in the fact that the opening has become closed through compression. The depression is situated below a distinct ridge extending from the dorsal border of the foramen magnum laterally and slightly upward, and it would appear as if a very small aperture was located here though no trace of it can be found' (Brink 1965: 102).

The next paragraph stated: 'To add to this very strange condition the post-temporal fossa, judging from the indication of it on the right forward side must have extended sharply laterally as it passed through from the posterior face

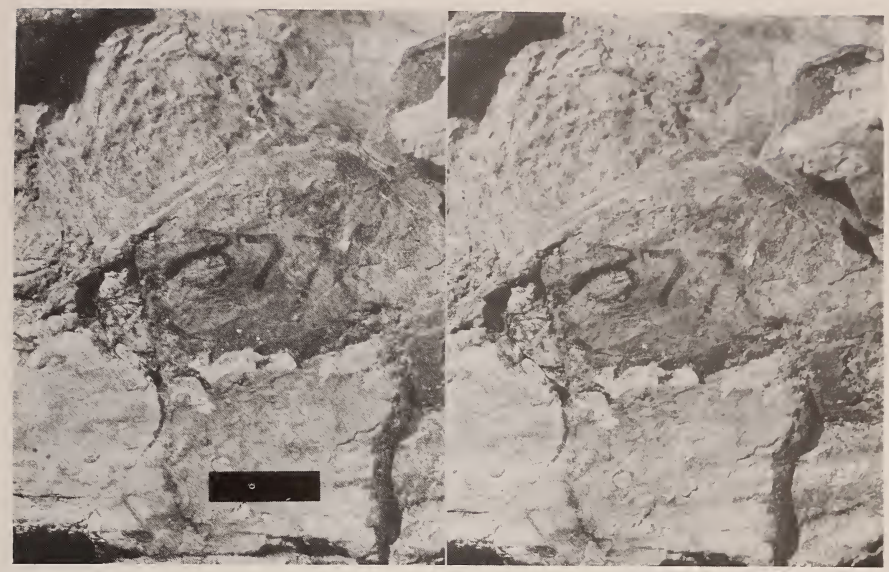

Fig. 7. Left side of the holotype of *Cragievarus kitchingi* showing the difference between the impression of the anterior border of the ascending ramus and the plaster reconstruction of the anterior border (white line) (cf. Figs 5–6). Scale in cm.

to the side of the temporal vacuity, but in both *Diademodon* and *Cynognathus* it extends inwards' (Brink 1965: 102).

The author finds it confusing that in the first of the two paragraphs quoted above the peculiar lack of a post-temporal foramen in this specimen was discussed at length, whilst in the second paragraph the peculiar course of the passage of this foramen was noted. It would appear that, although the openings of the post-temporal foramen could not be located, it was postulated that it opened anteriorly at the medial end of the 'small, shallow excavation' and posteriorly in the floor of the fossa bordering the foramen magnum. If this were the case, then the course of the canal's passage would be different from the direction it assumes in *Diademodon*.

Close examination of the back of this cranium revealed the presence of a matrix-plugged post-temporal foramen on the right side. The matrix that filled the foramen was carefully removed, and the foramen opens anteriorly where Brink (1965) suspected that it might. However, the posterior opening is considerably lateral to and above the level of the floor of the fossa where he postulated its exit to be (Fig. 8). This is the position normally occupied by this foramen in *Diademodon*, and it follows a nearly straight sagittal course as in *Diademodon*.

In a recent illustration of the occipital view of this specimen, Brink (1979: 44) indicated post-temporal foramina, and these are located in correct anatomical position, but an explanation of this new interpretation was not offered.

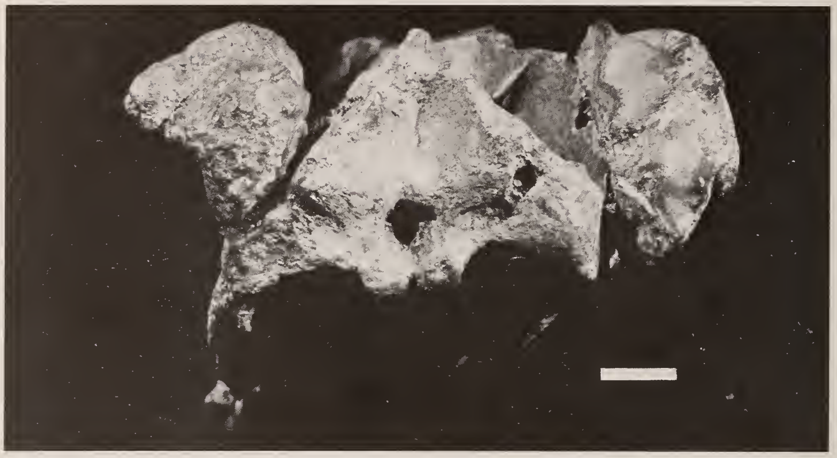

Fig. 8. Occipital view of the holotype of *Cragievarus kitchingi* showing the position of the right post-temporal foramen. Scale in cm.

Relative width of the braincase

In the original description of *Cragievarus kitchingi* (Brink 1965: 102), it was stated that 'proportionally the breadth across the braincase is greater than that of *Diademodon*'. At page 99 of the same paper, the maximum anterior and posterior breadths across the parietals were recorded as 17 mm and 10 mm respectively. However, comparable data for *Diademodon* upon which this assertion was based were not provided.

In the course of measuring *Diademodon* specimens for biometrical analysis, the present author has recorded the breadth of the parietals at the level of the pineal foramen (in an attempt to standardize this measurement) on a number of crania (Table 2). This measurement ranges between 6 and 25 mm in *Diademodon*; it is 14 mm in the type, and only specimen of *Cragievarus kitchingi*. The length of the cranium, from the level of a line tangential to the anterior border of the orbits anteriorly to the level of a line through the occipital condyles posteriorly, was measured also. This measurement, referred to as 'pre-orbital basal length' in previous studies (Grine & Hahn 1978; Grine, Hahn & Gow 1978; Bradu & Grine 1979), ranges between 21 and 158 mm in the present *Diademodon* sample; it is 61 mm in the type of *Cragievarus kitchingi*.

Comparison of 'pre-orbital' cranial length and parietal breadth in the present *Diademodon* sample (Fig. 9) indicates that, whilst the skull undergoes considerable ontogenetic elongation, there is little increase in the breadth of the brain-case with age. One *Diademodon* cranium in this sample (BPI.FN. 3773, one of the four *Diademodon* crania described by Brink (1963) from the Cragievar fossil pocket) has a 'pre-orbital basal length' which is the same as the type of *Cragievarus kitchingi*. The parietal breadth of the latter specimen is only 2 mm greater than that of the former.

TABLE 2

Measurements of cranial length, parietal breadth and indices of relative parietal breadth in diademodontine specimens of various sizes.

Catalogue no.	*Length*	*Parietal breadth*	*Index*	*Previous taxonomic designation*
BPI.FN. 3511	21	6	28,57	*Diademodon browni*
Munich 1936 II 8	32	8	25,00	*Sysphinctostoma smithi* (T)
BPI,FN.3756	36	12	33,33	*Diademodon mastacus*
BPI.FN. 3771	44	10	22,73	*Diademodon* sp.
BPI.FN. 3769	52	8	15,39	*Diademodon browni*
BPI.FN. 3776	**61**	**14**	**22,95**	**Cragievarus kitchingi** (T)
BPI.FN. 3773	61	12	19,67	*Diademodon browni*
Camb. T. 435	69	10	14,49	? *Protacmon* sp.
Munich 1934 VIII 14	72	12	16,67	*Gomphognathus ?browni*
Camb. T. 462	76	13	17,11	*Protacmon brachyrhinus* (T)
SAM – 1332	84	14	16,67	*Diademodon mastacus*
BMNH R. 3587/3588	84	14	16,67	*Gomphognathus minor* (T)
BMNH R. 3765/4092	86	13	15,12	*Diademodon entomophonus* (T)
BPI.FN. 3758	86	13	15.12	*Diademodon browni*
Munich 1934 VIII 15	92	13	14,13	*Gomphognathus* cf. *mastacus*
UCL. K. 11	100	14	14,00	*Diademodon* sp.
BMNH R.2578	103	14	13,59	*Diademodon polyphagus*
SAM – 5716	104	15	14,42	*Diademodon* sp.
BPI.FN. 4669	108	18	16,67	*Diademodon* sp.
Munich 1934 VIII 16	109	17	15,60	*Gomphognathus* cf. *mastacus*
Munich 1934 VIII 30	111	13	11,71	*Gomphognathus* cf. *mastacus*
USNM 23352	115	18	15,65	*Diademodon mastacus*
BPI.FN. 3639	118	21	17,80	*Diademodon rhodesiensis* (T)
Camb. T. 434	122	14	11,48	*Diademodon ?mastacus*
SAM – K. 5222	128	20	15,63	*Gomphognathus polyphagus*
Munich 1934 VIII 18	133	15	11,28	*Gomphognathus broomi* (T)
Munich 1934 VIII 17	142	17	11,97	*Gomphognathus grossarthi* (T)
Munich 1934 VIII 19	143	25	17,48	*Gomphognathus haughtoni* (T)
Camb. T. 436	149	17	11,41	*Diademodon laticeps* (T)
BPI. FN. 3754	158	23	14,56	*Diademodon grossarthi*

BPI.FN. = Bernard Price Institute for Paläeontological Research, Johannesburg
Munich = Bayerische Staatssammlung für Paläontologie, München
Camb. = University Museum of Zoology, Cambridge
SAM = South African Museum, Cape Town
BMNH = British Museum (Natural History), London
UCLZ = University College of London, Zoology Dept.
USNM = United States National Museum, Washington
(T) = holotype

An index of relative parietal breadth was calculated for each specimen according to the simple formula,

$$I = \frac{B}{L} (100)$$

where B is the breadth across the parietals and L is the 'pre-orbital basal' cranial length. The indices (Table 2) range between approximately 11,3 and 33.3 per cent of cranial length. When the index values are plotted as a function of 'pre-orbital' cranial length (Fig. 10), it becomes readily apparent that the

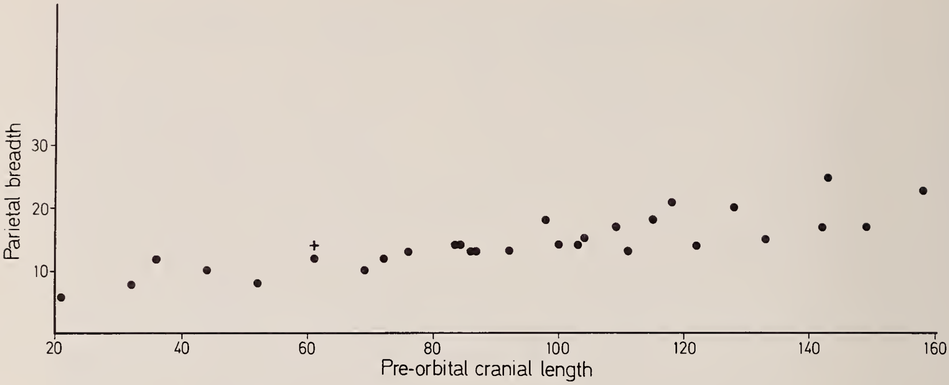

Fig. 9. Parietal breadth plotted as a function of cranial length in *Diademodon*. + = *Cragievarus kitchingi*. Scales in millimetre intervals. Note the slight increase in parietal breadth compared to the increase in cranial length.

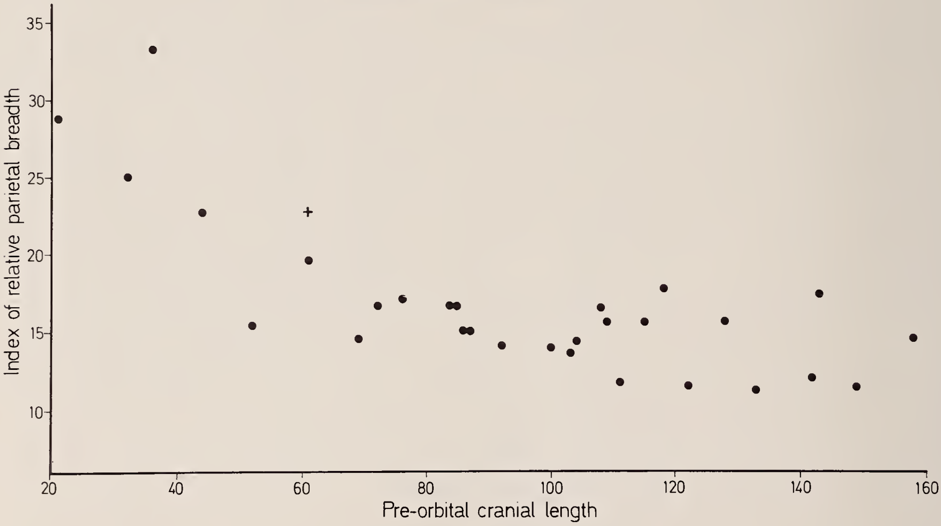

Fig. 10. Relative parietal breadth plotted as a function of cranial length in *Diademodon*. + = *Cragievarus kitchingi*. Ordinate scale in millimetre intervals, absissal scale in percentage intervals. Note the relatively greater parietal breadth of the smaller (ontogenetically younger) crania.

relative parietal breadth decreases, in an apparently exponential manner, as cranial length increases. The index of relative parietal width for *Cragievarus kitchingi* has a value of 22,95 per cent, which is slightly greater than that shown by BPI.FN. 3773 (19,67 per cent). But the relative width of the braincase of the smaller (ontogenetically younger) *Diademodon* specimens appears to be rather variable (Fig. 10), and the relative parietal width of *Cragievarus kitchingi* fits comfortably into the *Diademodon* 'growth velocity' curve.

In their preliminary study of relative growth in the cranium of *Diademodon*, Grine, Hahn & Gow (1978) noted that the variables related directly to the size of the brain (parietal width) and orbits exhibit definite negative allometry compared to total cranial length. This phenomenon may be expected in an ontogenetic growth series, as it is well known that in vertebrates the brain and eyes of younger (juvenile) individuals are relatively larger than in older (adult) individuals. Thus, the relatively broad diameter of the braincase of *Cragievarus kitchingi* is not abnormal when the specimen is considered in an ontogenetic context as one of the smaller (younger) *Diademodon* specimens present in the currently available sample (see Table 2 and Figs 9–10).

Height of the mid-sagittal parietal crest

In the description of *Cragievarus kitchingi*, it was stated that, 'in both *Diademodon* and *Cynognathus* . . . the parietals have a greater height at the level of the prootic than farther forward at the level of the alisphenoid. In the present specimen the height is greater in front' (Brink 1965: 102–103). However, examination of the original specimen reveals that the mid-sagittal crest has been broken away from the back of the skull to the level that Brink (1965) regarded as its highest point.

Dental formula

In the original description of the present specimen, it was noted that in the maxilla 'there are indications of sockets of two very small evidently conical teeth, at the front of the postcanine series . . .' (Brink 1965: 103). According to this 1965 diagnosis, this specimen possesses four incisors, one canine, two conical teeth and seven molariform teeth on each side of the upper jaw, and three incisors, one canine, no conical teeth and seven molariform teeth on each side of the lower jaw. The original illustration (Brink 1965, fig. 32) (Fig. 1 herein) shows the dental formula diagnosed for this specimen. In the later diagnosis of *Cragievarus kitchingi*, the presence of 'seven "molariform" cheek teeth, with indirect evidence of conical teeth anteriorly, [and] even less evidence of sectorials posteriorly' was noted (Brink 1979: 43). However, in the later illustration of this fossil (Brink 1979: 44) (Fig. 2 herein) eight maxillary and eight (? possibly nine) mandibular molariform teeth are depicted. Even if one allows that the two maxillary conical teeth were inadvertently represented as a single molariform tooth, this same allowance cannot be made for the lower jaw, for according to Brink's (1965) own diagnosis there are no mandibular conical teeth present.

It is not possible to either substantiate or refute the claim that the specimen possessed four incisors on either side of the upper jaw (Brink 1965), as the entire anterior end of the rostrum is missing. While it is conceivable that this number may be correct, it cannot be demonstrated, and therefore it cannot be used in a taxonomic diagnosis. Similarly, the anterior end of the mandibular symphysis is covered in matrix and without its removal the number of incisive alveoli cannot be determined accurately.

There is only a single canine on either side of the lower jaw and the broken alveolus of the left maxillary canine is preserved. The alveolus and root of the upper canine became visible after the matrix and plaster that covered them were removed.

As Brink (1965) noted, there are two alveoli preserved anterior to the first (preserved) molariform tooth in the right maxilla; this region on the left side is damaged. Because of the relatively small diameters of these two alveoli, it seems reasonable to assume, as did Brink, that they contained conical teeth.

On the right side there is a break through the dentary in front of the first (preserved) molariform tooth (Fig. 4). Immediately anterior to this break there is a small, circular alveolus. This was not visible previously because the region was covered in matrix. The relevant portion of the left dentary is missing. It would appear that the lower jaw supported at least one conical tooth in front of the molariform series.

Seven maxillary molariform teeth are preserved on the right side, and at least five mandibular molariform teeth are visible on this side. On the internal aspect of the right dentary, the crowns of seven mandibular molariform teeth have been exposed; the lateral aspects of the crowns of the last two teeth are covered by matrix. On the right exterior the area behind the last visible molariform teeth is covered by matrix.

On the left side, however, there are eight post-conical teeth in both the maxilla and mandible. The teeth are visible from the external aspect only, and some of the crowns have been damaged. The last few teeth were covered by the plaster used in the cranial and mandibular reconstructions (cf. Figs 5–6). Although the posterior teeth are damaged, it is evident that the last mandibular and probably the last maxillary crowns are those of sectorial teeth.

In addition, removal of the plaster from the left side revealed two additional crowns behind the eighth mandibular tooth. The crowns of these last two teeth, although damaged, are mesiodistally elongate and buccolingually compressed. They appear to be sectorial teeth also. Because of their position and orientation it seems that these last two teeth had probably not yet erupted at the time of death of this individual.

Thus, according to the evidence provided by the prepared specimen, it appears that the maxilla contained perhaps two conical teeth, seven molariform teeth and one sectorial tooth, and that the mandible supported at least one conical tooth, seven molariform teeth and one sectorial tooth. Also, it is evident that there are at least two sectorial teeth contained in the dentary behind the sectorial tooth noted above; it appears that these latter two teeth had not yet erupted at the time of death.

The postcanine dental formula indicated above may be incorrect in so far as the numbers of the various postcanine tooth types are concerned, but it has been pointed out elsewhere (Grine 1977, 1978*b*; Grine, Hahn & Gow 1978) that in view of the type of replacement exhibited by *Diademodon*, postcanine tooth number is of limited diagnostic importance.

The diagnostic statement that there is 'indirect evidence of conical teeth anteriorly, and even less evidence of sectorials posteriorly' (Brink 1979: 43) is shown to be erroneous following a re-examination of the type specimen. Whilst the presence of conical teeth is inferred from alveoli, the actual crowns of the sectorial teeth are present.

Maxillary diastema

In the earlier description of the present specimen (Brink 1965: 103) it was stated that, 'there are indications of sockets of two very small evidently conical teeth, at the front of the postcanine series, with an unusually extensive diasteme separating them from the approximate position of the canine. The diasteme is actually preserved for a distance of fourteen millimetres in which there is no trace of a socket, even of a tooth long since lost, and this distance is reflected in the figures, but as there is no sign of the canine on either side, the diasteme may in fact be longer. It cannot possibly be shorter. This is a very conspicuous diagnostic feature of this new genus and species.'

On the right side the maxilla is broken posterior to the level of the canine. The distance between the mesial edge of the first molariform tooth to the edge of this break measures approximately 10,5 mm; and the distance between the mesial edge of the anterior 'conical' socket and the break measures some 7,0 mm. The distance between the mesial face of the first molariform tooth and the mesial edge of the first 'conical' socket measures about 3,5 mm.

As noted previously, the left canine socket and the damaged root which it contains have been exposed. The distance on this side between the mesial face of the first molariform tooth and the distal edge of the canine socket measures some 14,5 mm. The sockets of the left conical teeth have been damaged, but if one allows that the combined mesiodistal dimension of these teeth was the same as on the opposite side, then 3,5 mm may be subtracted from the above figure of 14,5 mm. The result is that the diastema separating the canine from the first conical tooth is closer to 11,0 mm than 14,0 mm; the distance between the first molariform tooth and the canine is about 14,0 mm.

In the earlier illustration of this specimen (Fig. 2 herein) the length of the diastema that is shown is 3,5 mm (Brink 1979: 44); the figure is reduced by half from actual size, and if the distance depicted is multiplied by two, the resultant length of the diastema is only 7,0 mm.

A diastema of some 11,0 mm (as determined by the present author) is not 'unusually extensive', in fact, neither is one of 14,0 mm for a *Diademodon* cranium of similar size.

Replacement of alisphenoid by the quadrate ramus of the pterygoid

Brink (1965: 105) noted that in the type of *Cragievarus kitchingi* 'the alisphenoid of the right side is exposed over its dorsal region and would appear to be typically diademodontid. Below, it definitely interferes with the pterygoid extension to the quadrate, but it seems as if it does not reach as far laterally.'

He also noted that, 'although there is clear interference on the part of the alisphenoids farther back, it would appear that the pterygoids themselves still reach the quadrates, as is characteristic of *Protacmon*'.

In a later paper it was noted that, 'from a very poor specimen it is interpreted in the illustrations that the pterygoids reach back to the quadrates, in which case *Cragievarus* is well separated from *Diademodon*. Watson (1920) created the genus *Protacmon* on the strength of a similar interpretation, and this is now regarded as a misinterpretation, and this may apply also to *Cragievarus*' (Brink 1979: 7).

The quadrate processes, whether they are formed by the alisphenoids or the pterygoids, are very poorly preserved. Both are distorted, they are covered with numerous cracks and a considerable amount of surface bone has been lost. Because of these factors the presence of a definite pterygo-alisphenoid suture could not be located. By the same token, the presence of this suture cannot be ruled out. The bone of this region is too poorly preserved to permit a definite confirmation or refutation of the earlier claim (Brink 1965), which Brink (1979: 7) later noted may be a misinterpretation.

Divergence of the quadrate rami of the pterygoid

In the original description (Brink 1965) it was noted that the quadrate rami of the pterygoid begin to diverge posterolaterally farther forward in *Cragievarus kitchingi* than is typical of *Diademodon*. This feature was added to the re-diagnosis of the former taxon (Brink 1979: 7).

The level at which the quadrate processes diverge is variable in *Diademodon*, and it appears to be related, to a certain extent, to cranial size. Even in crania of similar size there seems to be a certain amount of individual variation. Some idea of the amount of variation may be gained from an examination of Brink's (1979) illustrations of different *Diademodon* crania.

The outlines of the quadrate rami of *Cragievarus kitchingi* and four *Diademodon* specimens of similar size are presented in Figure 11. These outlines are adapted from Brink's (1979) drawings of the specimens and they serve to indicate the type of variation encountered.

Whilst the quadrate rami of *Cragievarus kitchingi* diverge somewhat further forward than in some *Diademodon* specimens (e.g. Fig. 11A–B) their level of divergence is comparable to that shown by other *Diademodon* specimens (e.g. Fig. 11C–D).

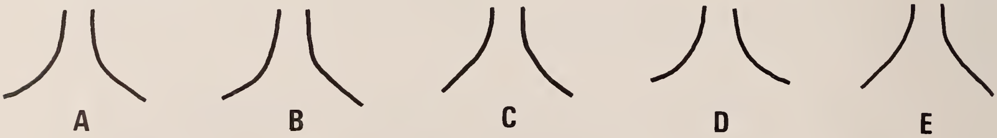

Fig. 11. Schematic outlines of diademodontine cranial bases to show the variation in the level of divergence of the quadrate rami. Specimens of similar cranial size. A–D. *Diademodon*. E. *Cragievarus*. A. Munich 1934 VIII 18. B. BPI.FN. 3769. C. BPI.FN. 3773. D. Camb. T. 462. All modified from Brink (1979). See text for explanation.

DISCUSSION

Cragievarus kitchingi was erected on the basis of an incomplete and poorly preserved skull of a gomphodont cynodont. In their taxonomic revision of the cynodonts, Hopson & Kitching (1972) proposed that *Cragievarus kitchingi* is a junior synonym of *Diademodon tetragonus*. Because of its incompleteness, the type of *Cragievarus kitchingi* was not included in the biometrical analyses of diademodontine crania (Grine & Hahn 1978; Grine, Hahn & Gow 1978; Bradu & Grine 1979). Recently, Brink (1979) has 'reinstated' *Cragievarus kitchingi* as a valid taxon within the Diademodontinae.

An examination of the type of *Cragievarus kitchingi*—no other specimen has been referred to this taxon (Brink 1979)—has revealed that most of its supposed diagnostic features are based upon (i) hypothetical plaster reconstruction (e.g. the lack of the jugal flange and the slight curvature of the temporal arch), (ii) the misinterpretation of damage for 'true' anatomical features (e.g. the forward height of the mid-sagittal crest and the foreshortened postero-inferior margin of the temporal arch), (iii) inaccurate plaster reconstruction (e.g. the powerful expansion of the ascending ramus of the dentary), (iv) incomplete preparation (e.g. the lack or supposed disposition of the post-temporal foramen, the lack of mandibular conical teeth and the length of the maxillary diastema), and (v) the obliteration of features by plaster (e.g. the lack of posterior sectorial teeth).

Other supposedly diagnostic characters (e.g. the relative width of the braincase and the level at which the quadrate rami diverge) have been shown here to be invalid when the size of the type specimen and the degree of variability of these features in *Diademodon* are considered. Another supposedly diagnostic feature of *Cragievarus kitchingi*, the replacement of the alisphenoid by the quadrate ramus of the pterygoid, can be neither substantiated nor refuted because of the poor preservation of the region. The validity of this last character has been questioned also by Brink (1979).

Furthermore, it has been shown upon removal of the plaster and further preparation that the specimen evinces no morphology by which it can be distinguished from *Diademodon*.

This specimen was recovered from the same fossil 'pocket' that yielded a number of *Diademodon* crania (Brink 1963; Kitching 1963). Kitching (1977) has stated that he believes these closely associated diademodontine specimens to be conspecific, and that the type of *Cragievarus kitchingi* represents a 'distorted growth stage' of *Diademodon tetragonus*. It is perhaps significant that whilst there are well over 100 available diademondontine skulls, crania, and mandibles from the South African *Cynognathus* Zone (= *Diademodon–Kannemeyeria* Assemblage Zone), neither Brink (1979) nor any other worker has been able to assign any of these remains, other than the holotype, to *Cragievarus kitchingi*.

CONCLUSIONS

The supposed diagnostic features of *Cragievarus kitchingi*, as preserved on the type and only specimen of this taxon, have been re-examined and shown to be invalid. The type displays no morphology by which it can be distinguished from *Diademodon*. As a result, the name *Cragievarus kitchingi* Brink, 1965, is considered to be a subjective junior synonym of *Diademodon tetragonus* Seeley, 1894.

Kitching's (1977) proposal that this specimen is a 'juvenile' individual of *Diademodon tetragonus* is supported.

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